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(54) **Method for preparing foreign protein in yeast, recombinat DNA, transformant.**

(57) A method for preparing foreign protein in yeast using an expression recombinant DNA comprising DNA encoding the serum albumin signal peptide adjacent to DNA encoding the foreign protein is disclosed.

METHOD FOR PREPARING FOREIGN PROTEIN IN YEAST, RECOMBINANT DNA, TRANSFORMANT

FIELD OF THE INVENTION

This invention relates to a method for preparing foreign protein in yeast using an expression recombinant DNA comprising DNA encoding the serum albumin signal peptide adjacent to DNA encoding the foreign protein.

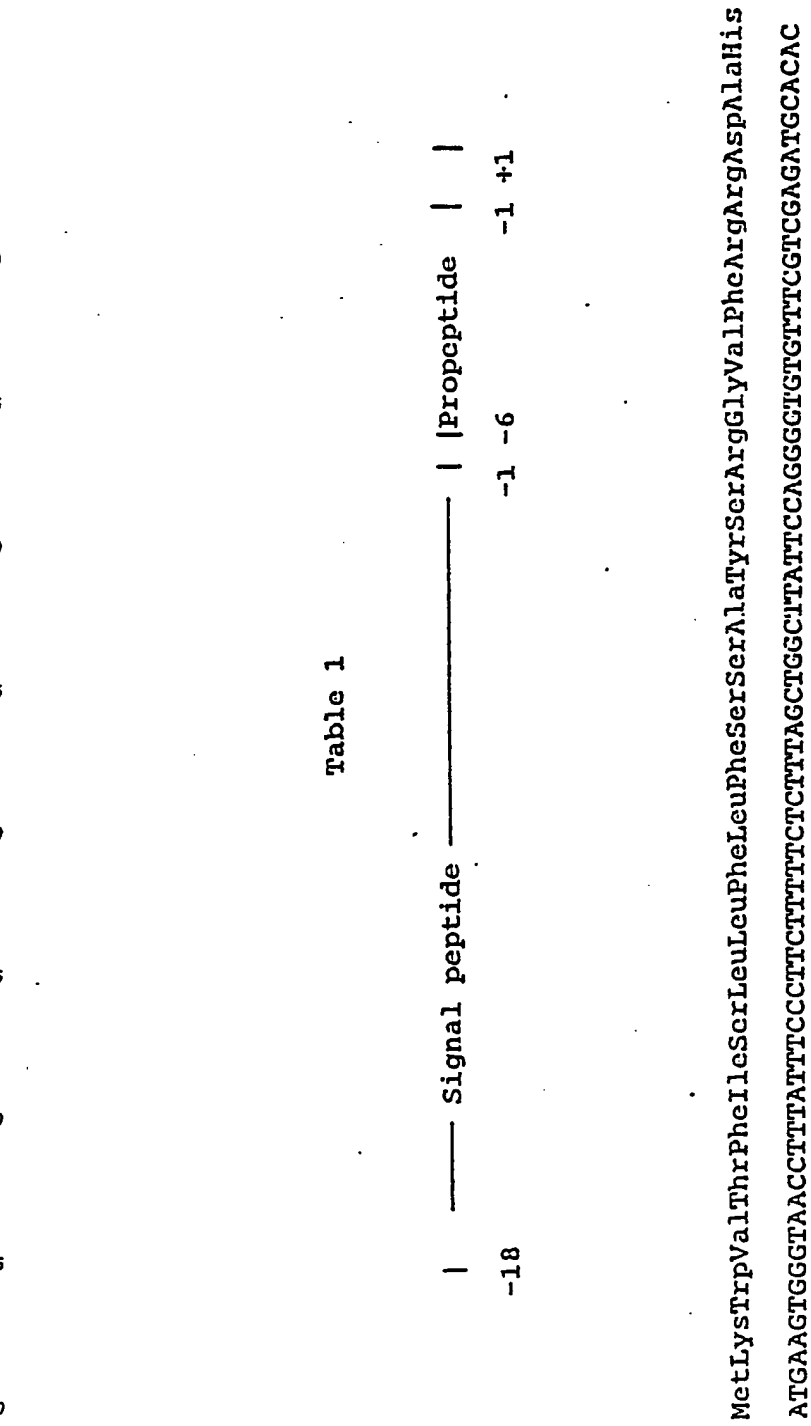
BACKGROUND OF THE INVENTION

In the production of specific proteins in a recombinant host by recombinant DNA technology, there are many advantages to having the host express and secrete the desired protein. That is, when a desired protein is expressed directly within the host cell, if there is any toxicity which inhibits growth or compromises the survival of the host cell, this toxicity can be avoided by the secretion of the protein. Even when there is no toxicity, as the protein accumulates in the host cell, it may inhibit the host cell growth. This, too, can be avoided by secretory expression. In addition, systems which accumulate protein in the host cell may also denature it, rendering it insoluble. This problem also can be avoided by secretory expression. Moreover, when commercially producing protein by recombinant DNA technology in a system which accumulates the desired protein intra cellularly, it is necessary to destroy the cell in order to refine the protein, and it must be purified from the debris of the cellular destruction. This makes it difficult to obtain a protein of high purity. On the other hand, when producing a protein by a secretory expression system the protein only must be harvested from the culture broth, minimizing the problem of separating impurities derived from the recombinant host. This is a great advantage. Finally, most protein undergoes some modification, such as the addition of a sugar moiety, the formation of a disulfide bond, activation by limited hydrolysis of the inert proprotein, phosphorylation of specific amino acids, or carboxylation before activation. Some of these functions are performed by the themselves, and several of these modifications take place in the process of secretion. Therefore, a system which produces protein by secretory expression, as compared to a system which accumulates protein intracellularly, may be expected to generate proteins having a structure and function much close to the native protein.

Somethings are known about the properties of the signal peptide, and the characteristics of its amino acid sequence seem to be as follows. There are many basic amino acids near the N-terminal, and there are many polar amino acids near the portion which is digested by signal peptidase on the C-terminal side, while a sequence hydrophobic amino acids fill in the space between these two areas. The basic amino acids near the N-terminal interact with the phospholipids on the internal surface of the cell membrane, and the sequence of hydrophobic amino acids in the middle region playes an important role in passing the protein through the cell membrane. The polar amino acids at the C-terminal are believed to play some role in recognition during digestion by signal peptidase. These characteristics are extremely similar from procaryotes to higher animals, suggesting a common mechanism for protein secretion. (M.S. Briggs and L.M. Gierasch, Adv. Protein Chem., 38, 109-180 (1986); G. von Heijne, EMBO J., 3, 2315-2318 (1984)).

Human serum albumin is encoded on the gene as a prepro type protein (see Japanese Patent Application (OPI) No. 29985/87 (the term OPI used herein means an unexamined published application.) or EP-A-206733; A. Dugaiczyk et al. Proc. Natl. Acad. Sci. USA, 79, 71-75 (1982)). The DNA and amino acid sequence in the vicinity of the N-terminal of mature human serum albumin beginning from the signal peptide essential for secretion are shown in Table 1 below.

Table 1



The singal peptide, composed of 18 amino acid is removed at the time of secretion. The propeptide, composed of 6 amino acids, is removed by processing, and mature human serum albumin, composed of 585 amino acids, and having an N-terminal amino acid sequence of Asp-Ala-His-Lys-Ser ..... , is obtained.

Since yeast secrete less extracellular proteases and are capable of adding sugar moieties to its secreta, yeast is excellent for the secretory expression of foreign proteins.

Several cases of signal peptides which contributes to the secretory expression in cells other than yeast,

but which also function in yeast, have been reported. Examples include the secretory expression in yeast of human lysozyme using the chicken lysozyme signal peptide (Jigami, BIOINDUSTRY, 4, 117-123 (1987)), secretory expression in yeast of thaumatin using the signal peptide for plant protein thaumatin (L. Edens, I. Bom, A.M. Ledeboer, J. Maat, M.Y. Toonen, C. Visser and C.T. Verrips, Cell, 37, 629-633 (1984)), and secretory expression in yeast of human interferon using the signal peptide for human interferon-α (R.A. Hitzeman, D.W. Leung, L.J. Perry, W.J. Kohr, H.L. Levine and D.V. Doeddel, Science, 219, 620-625 (1983)).

The truth is, however, that the signal peptide contributing to secretory expression in cells other than yeast does not always function in yeast.

SUMMARY OF THE INVENTION

Therefore, a primary object of this invention is to provide a method for expressing and secreting foreign protein efficiently in yeast, the signal peptide gene functionable in yeast for secretory expression, the vector to be used in this method, and the transformant transformed by this vector.

The above-described object of the present invention has been met in one embodiment by a method for preparing foreign protein comprising expressing and secreting said foreign protein by yeast transformed by a recombinant DNA comprising the serum albumin signal peptide gene adjacent to the gene of said foreign protein. In a second embodiment, the present invention relates to a serum albumin signal peptide gene and derivatives thereof. In a third embodiment, the present invention relates to a recombinant DNA for transforming yeast comprising DNA encoding the serum albumin signal peptide adjacent to DNA encoding a foreign protein. In a forth embodiment, the present invention relates to a strain of yeast transformed by a recombinant DNA comprising DNA coding for the serum albumin signal peptide adjacent to DNA encoding a foreign protein.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows the procedure for making pGAL12 from pGAL11 possessing the GAL1, 10 promoters.

Fig. 2 shows the procedure for making pPT1, containing only the pho5 terminator, from pAP5 and pUC9 containing the entire pho5 gene.

Fig. 3 shows the procedure for making pPT2 from pJDB207.

Fig. 4 and Fig. 5 show the restriction enzyme map of pGX401 containing the prepro human serum albumin gene.

Fig. 6 shows the procedure for making pHSA2, containing the human serum albumin gene C-terminal side from pGX401 and pUC19.

Fig. 7 shows the procedure for making pHSA1, containing the human serum albumin gene N-terminal side, from pGX401 and pUC19.

Fig. 8 shows the procedure for making pNH001, containing the signal peptide gene and the mature human serum albumin gene, from pHSA1, pHSA2 and the synthesized signal peptide gene.

Fig. 9 shows the procedure for making pNH007, containing the GAL1 promoter, signal peptide gene and mature human serum albumin gene, form pNH001 and pGAL12.

Fig. 10 shows the procedure for making pNH008, containing the GAL1 promoter, signal peptide gene, mature human serum albumin gene and pho5 terminator, from pNH007 and pPT2.

DETAILED DESCRIPTION OF THE INVENTION

The recombinant DNA of this invention comprises the serum albumin signal peptide gene, the foreign protein gene, a promoter, a terminator, and the plasmid DNA or chromosome DNA.

The origin of the serum albumin signal peptide gene is not specifically defined as long as it is derived from mammals. Practically, human-derived, rat-derived and bovine-derived preparations can be used.

Examples of the amino aicd sequences of such signal peptides are known to include;

Met Lys Trp Val Thr Phe Ile Ser Leu Leu Phe Leu Phe Ser Ser Ala Tyr Ser derived from humans;

Met Lys Trp Val Thr Phe Leu Leu Leu Leu Phe Ile Ser Gly Ser Ala Phe Ser derived from rats; and

Met Lys Trp Val Thr Phe Ile Ser Leu Leu Leu Leu Phe Ser Ser Ala Tyr Ser derived from cows.

However, preferably, the human serum albumin signal peptide gene is used and the 2nd amino acid and the last five amino acids can be changed by Y and Xs as the following sequence.

Met Y Trp Val Thr Phe Ile Ser Leu Leu Phe Leu Phe X_5 X_4 X_3 X_2 X_1

wherein Y represents lys, Arg or His and preferably represents Lys; X_5 represents Ala, Pro or Ser; X_4 represents Lys, Gly or Ser; X_3 represents Ala, Val or Cys and preferably represents Val or Cys; X_2 represents Tyr, Trp or Ser; and X_1 represents Ser, Ala or Gly and preferably represents Ala or Gly. Preferable examples of amino acid sequences of the signal peptides are shown in Table 2 below.

Table 2

Sequence No.	Y	X_5	X_4	X_3	X_2	X_1
Sequence 1	Lys	Ser	Ser	Val	Tyr	Ala
Sequence 2	Lys	Ala	Lys	Val	Ser	Ala
Sequence 3	Lys	Pro	Gly	Cys	Trp	Ala
Sequence 4	Lys	Pro	Gly	Val	Trp	Ala

The serum albumin signal peptide gene may possess a DNA sequence which can be expressed by the amino acid sequence shown above, and one example is having the following DNA sequence.

ATGAAGTGGGTAACCTTTATTTCCCTT
CTTTTTCTCTTTAGCTCGGCTTATTCC

Preferable codons corresponding to each amino acid are set forth below.

Ala: GCT or GCC,	Cys: TGT,	Asp: GAC,
Glu: GAA,	Phe: TTC,	Gly: GGT,
His: GAC,	Ile: ATT or ATC,	Lys: AAG,
Leu: TTG,	Met: ATG,	Asn: AAC,
Pro: CCA,	Gln: CAA,	Arg: AGA,
Ser: TCT or TCC,	Thr: ACT or ACC,	Val: GTT or GTC,
Trp: TGG,	Tyr: TAC	

As the foreign protein in this invention, human serum albumin, interferon-α, -β, or -γ, urokinase, growth hormone, insulin, Factor VIII, EPO, h-ANP, M-CSF and various lymphokines may be used.

In the case of human serum albumin, pre type, pro type, or prepro type may be used, and in the case of urokinase, pro type or any other type may be used. Among foreign proteins, in particular, a mature human serum albumin gene is preferable. According to the present invention, in the case that the mature human serum albumin gene is positioned immediately downstream to the serum albumin signal peptide gene, a substantial quantity of albumin can be produced.

Such foreign protein genes have been described in Japanese Patent Application (OPI) No. 29985/87 or EP-A-206733 (human serum albumin), Japanese Patent Application (OPI) No. 185189/86 or DE-A-3603958 (interferon-α), Japanese Patent Application (OPI) No. 108397/86 or EP-A-190686 (interferon-γ), Japanese Patent Application (OPI) No. 180591/85 or EP-A-154272 (urokinase), EP-A-160457 (Factor VIII), EP-A-148605 (EPO), WO85-4670 (h-ANP), WO86-4607 (M-CSF), and others.

In the above publications, the inventions are described as plasmids containing foreign protein genes.

The recombinant DNA for transforming yeast in this invention is prepared by linking the foreign protein gene downstream to the serum albumin signal peptide gene.

The promoter and terminator are not specifically limited to those found in yeast.

Acceptable promoters include PGK promoter (Nucleic Acid Res., 10(23), 7791 (1982)), ADH promoter (ibid.), phoE (5) promoter (J. MOl. Biol., 163(4), 513 (1983)), GAL1 promoter (Mol. Cell. Biol., 4(11), 2467 (1984)), GAL10 promoter (EP-A-132309) and GAP-DH promoter (J. Biol. Chem., 258, 5291 (1983)). Among these promoters, GAL1 promoter is particularly preferable.

The promoter is positioned upstream to the serum albumin signal peptide gene.

Acceptable terminators include the phoE(5) terminator (Cell, 12, 721-732 (1977)) and the GAP-DH terminator (J. Biol. Chem., 254, 9839-9845 (1979)).

The terminator is positioned downstream to the foreign protein gene.

The promoter and terminator may be obtained in a form already incorporated into plasmids.

The plasmid DNA must be capable of self-replication in yeast.

Acceptable examples are pJDB207 (Amersham) and pJDB219 (Amersham).

The recombinant plasmid of this invention is obtained either by cleaving a DNA sequence composed of the serum albumin signal peptide gene-foreign protein gene, a DNA sequence containing the promoter, and a DNA sequence containing the terminator from the above plasmid groups by a restriction enzyme and coupling (connecting) them to incorporate them into a proper plasmid, or by cleaving one DNA sequence and then incorporating it into another plasmid.

Also, the recombinant chromosome of this invention is obtained by insertion of a DNA sequence comprising the serum albumin signal peptide gene-foreign protein gene, a DNA sequence containing the promoter, and a DNA sequence containing the terminator into the yeast chromosome. The detail methods have been described in Proc. Natl. Acad. Sci. USA, 78, 6354-6358 (1981) and Method Enzymol., 101, 228-245 (1983).

The DNA sequence on the plasmid or the chromosome is arranged, from upstream to downstream, in the order of the promoter, serum albumin signal peptide gene, foreign protein gene, and terminator.

As the marker for selecting the desired plasmid, it is also possible to incorporate an antibiotic (tetracycline, ampicillin, kanamycin) resistance gene, or a gene to compensate for a nutritional requirement of the host. The method of preparing a transformant by this recombinant plasmid or the method of preparing a foreign protein is as follows.

The recombinant plasmid is introduced into the host cell i.e., yeast. Practically, a strain having a variation which is complemented by the selective marker gene carried by the plasmid to be inserted, for example, Saccharomyces cerevisiae AH22 (a, his4, leu2, can1) which is a leucine-requiring variant is acceptable for use.

Transformation of the host cell (yeast) is conducted by an established method, for example, the calcium phosphate sedimentation method, protoplast-polyethylene glycol fusion method, electropolation method.

The transformant is incubated in an established culture medium for the growth of the host cell. Practical examples of culture medium are YNB liquid culture medium (0.7 w/v% yeast nitrogen base (Difco Co.) and 2 w/v% glucose), YPD liquid culture medium (1 w/v% yeast extract (Difco), 2 w/v% polypeptone (Daigo Eiyo Sha), 2 w/v% glucose) and others.

Incubation is performed for 20 to 100 hours, usually at 15 to 43° C (preferably about 30° C), while being aerated or stirred as required.

After cultivation, the culture supernatant is recovered, and the foreign protein is purified by an established method, such as affinity chromatography or fractionation.

By using the method of this invention, a desired foreign protein can be produced by secretory expression. Compared with the system intracellular accumulation, production of the protein possessing structure and function much close to the native protein may be expected.

Additionally, in the system of intracellular accmulation, it is necessary to destroy the cells to refine the protein and to purify the protein from the liquid which contains debris, but this type of purification process is unnecessary when the method of this invention is used.

The use of the serum albumin signal peptide in expression of the protein also allows the development of the new secretory expression method. This increases the potential usefulness of this invention considerably.

This invention is described in further detail below by referring to the following Example, which, however, is not intended to limit this invention in any respect.

Many of the techniques, reactions and analytical methods used in this invention are well known in the art. Unless otherwise specified, all enzymes can be obtained from commercial supply sources: for example, Takara Shuzo, Japan; New England Biolabs (NEB), Massachusetts, USA; Amersham, England; and Bethesda Research Laboratories (BRL), Maryland, USA.

Buffer solutions for enzymatic reactions and reaction conditions conformed to the recommended specifications of the manufacturers of the enzymes unless otherwise noted.

The transformation method of Escherichia coli by plasmid, colony hybridization, electrophoresis, and DNA recovery method from gels were conducted in accordance with the methods mentioned in "Molecular Cloning", Cold Spring Harbor Laboratory (1982). Yeast was transformed by the method stated in "Method in Yeast Genetics", Cold Spring Harbor Laboratory (1981).

EXAMPLE

Cloning of yeast GAL1, 10 promoters

(A) Preparation of yeast chromosomal DNA library

The chromosomal DNA of the yeast Saccharomyces cerivisiae GRF18 PHO80 cir^0 strain (as described in EP-A- 0180958 was extracted and purified by the method described by R. Cryer et al., (Method Enzymol., 12, 39 (1975)).

According to M. Mohnson and R.W. Davis (Mol. Cell. Biol., 4, 1440-1448 (1984)), the yeast GAL1, 10 promoter regions are located on the yeast chromosome, and when it is digested by the restriction enzymes EcoRI and XbaI, DNA segments of about 1 kb are obtained. Hence, yeast chromosomal DNA, extracted and purified as described above, was digested by EcoRI and XbaI, and DNA segments of about 1 kb were isolated by electrophoresis. These segments were mixed with plasmid pUC19 (BRL) which was digested by EcoRI and XbaI, and dephosphorylated at its 5′ terminal with alkaline phosphatase derived from calf intestines (CIP). These were ligated using the ligation kit (Takara Shuzo). This product was introduced into Escherichia coli JM109 (Takara Shuzo). The transformant was applied to a YT agar plate containing 0.004 w/v% X-gal (5-bromo-4-chloro-3-indolyl-β-galactoside) and 1 mM IPTG (isopropyl-β,D-thiogalactopyranoside), and was incubated overnight at 37° C. (To prepare the agar plate 8 g of polypeptone, 5 g of yeast extract, and 5 g of sodium chloride were dissolved in water to make up 1 liter and 12 g of agar powder was added. After sterilizaiton in an autoclave, the mixture was dispensed into plastic Petri dish and solidified; X-gal and IPTG were added after autoclaving once the culture medium had cooled.)

White and blue colonies appeared, and only the white clonies having the DNA inserts were used. (The desired transformant produced white colonies since the recombinant plasmid inserted therein had no lac Z gene.) One hundred colonies were inoculated onto an L-agar plate containing 40 μg/mℓ ampicillin by a sterilized toothpick. (To prepare the agar plate 0.62 g of tris base, 10 g of polypeptone, 5 g of yeast extract, and 5 g of sodium chloride were dissolved in water to make up 1 liter, and 12 g of agar powder was added. The mixture was sterilized in an autoclave, dispensed into plastic Petri dish and solidified: ampicillin added, after autoclaving once the medium had cooled.) This L-agar plate was incubated overnight at 37° C. By this method, a library consisting of about 5,000 colonies was prepared. The formed colonies were transferred to a nitrocellulose filter, dipped in a solution of 0.5 M sodium hydroxide and 1.5 M sodium chloride to denature the DNA, and were neutralized in a solution of 1.5 M sodium chloride and 0.5 M tris-hydrochloric acid at pH 7.5. The E. coli debris was washed with 2 x SSC (0.3 M sodium chloride, 0.03 M sodium citrate at pH 7.0) and removed, and after drying the filter in air, it was subjected to vacuum drying for 2 hours at 80° C.

(B) Preparation of the probe

Part of base sequence of the gene coding for the GAL1, 10 promoters was synthesized by the phosphoramidite method using a DNA synthesizer, Applied Biosystem Co. model 381A. Its sequence is shown below.

5′-CTCTATACTTTAACGTCAAG-3′

The sequence was subjected to electrophoresis using 7 M urea-20 w/v% polyacrylamide gel and purified. The 5′ terminal of the purified DNA sequence was labeled radioactively by [γ-^{32}P] ATP and T4 polynucleotide kinase. The reaction using 10 pmoles of synthetic DNA, 250 μCi of [γ-^{32}P] ATP, and 8 units of T4 polynucleotide kinase, resulted in a synthetic DNA probe terminally labeled with ^{32}P (2 x 10^7 cpm (Cerenkov count)). The synthetic DNA probe was purified by NENSORB 20 (Du Pont).

(C) Screening of GAL1, 10 promoters

Nitrocellulose filters having the DNA fixed as described in step (A) were placed in vinyl bags with each set containing 10 filters, and the following process carried out. Ten milliliters of prehybridization solution composed of 6 x SSC, 0.1 w/v% SDS, and 20 μg/mℓ of salmon sperm DNA cooled on ice after heating for 5 minutes at 100° C was put in a vinyl bag which was sealed and incubated for 3 hours at 40° C. The prehybridization solution was then discarded and 10 mℓ of hybridization solution was added and incubated overnight at 40° C. The hybridization solution contained 6 x SSC, 0.1 w/v% SDS, 100 μg/mℓ salmon sperm DNA, and 7.5 x 10^5 cpm/mℓ ^{32}P-probe. After incubation, the filter was transferred to a beaker and washed in 6 x SSC, 0.1 w/v% SDS for 30 minutes at 50° C, in 2 x SSC and 0.1 w/v% SDS for 30 minutes at 50° C, in

2 x SSC and 0.1 w/v% SDS for 30 minutes at 50°C, and finally in 0.1 x SSC and 0.1 w/v% SDS for 30 minutes at 50°C. The washed filter was dried in air and subjected to autoradiography after applying spotting marks of 100-200 cpm. As a result, two positive clones were obtained. One of the clones was subjected to shaking culture overnight at 37°C in super broth containing 40 μg/mℓ of ampicillin. (To prepare the super broth 12 g of bactotrypton, 24 g of yeast extract, and 5 mℓ of glycerol were dissolved in water to make up 900 mℓ, which was sterilized by autoclave to obtain solution A. Then, 3.81 g of potassium dihydrogen phosphate and 12.5 g of potassium monohydrogen phosphate were dissolved in water to make up 100 mℓ, which was sterilized by autoclave to obtain solution B. These solutions A and B were mixed in a ratio of 9:1 by v/v.) Then, the plasmid DNA was extracted and purified by the alkaline-SDS method.

When part of the base sequence of this plasmid DNA (pGAL11, Fig. 1) was examined by the dideoxy method, the results coincided with the reported sequence by M. Johnston and R.W. Davis (Mol. Cell, Biol., 4, 1440-1448, (1984)). That is, it was found that pGAL11 possessed the GAL1 promoter in the direction of the XbaI site from the EcoRI site, and the GAL10 promoter in the opposite direction.

(D) Conversion of pGAL11 from the XbaI site to the BamHI site

When ligating the promoter sequence on pGAL11 with the DNA sequence coding for the signal peptide and human serum albumin, it is not convenient to have an intervening XbaI site because the XbaI site is present on the human serum albumin gene. Therefore, the XbaI site was converted to the BamHI site as follows.

After digesting pGAL11 by XbaI, the sticky end was repaired by E. coli-derived DNA polymerase I, Klenow fragment, in the presence of dGTP, dATP, dTTP, dCTP. To this DNA fragment, the BamHI linker pCGGATCCG having a phosphorylated 5′ terminal was added and was ligated by T4 DNA ligase. After then digesting with BamHI, ligation was again carried out with T4 DNA ligase and the resulting plasmid introduced into E. coli HB101 (EP-A-13828). From the resulting transformants, a clone having plasmid pGAL12 (as shown in Fig. 1) was obtained. By digesting pGAL12 by EcoRI and BamHI, the GAL1 and GAL10 promoters could be isolated as a DNA fragment of about 1 kb.

(E) Preparation of E. coli-yeast shuttle vector pPT2 possessing a yeast pho5 terminator

The plasmid pAP5 which has encoded the Saccharomyces serevisiae pho5 gene is disclosed in Japanese Patent Application (OPI) No. 151183/87 or EP-A-216573. This plasmid was digested by the restriction enzymes Sau3AI and PstI, and the DNA fragment which has encoded the pho5 terminator, about 370 bp, was isolated by electrophoresis (Fig. 2). The commercially available pUC9 (BRL) was then digested with BamHI and PstI, treated with alkaline phosphatase, and ligated with the 370 bp DNA fragment. The base sequence at the Sau3AI cleavage site of the 370 bp fragment was

GATCC.....

G.....

and when it was ligated with the sticky end of the BamHI, the BamHI site was regenerated. Therefore, by digesting plasmid pPT1 obtained in the above ligation reaction with BamHI and PstI, or by digestion with BamHI and HindIII, a DNA fragment possessing a 370 bp pho5 terminator was obtained (Fig. 2). The commercially available shuttle vector pJDB207 (Fig. 3) is self-replicating in E. coli and yeast. After digestion with BamHI and HindIII, it was treated with alkaline phosphatase. After digesting pPT1 with BamHI and HindIII, the DNA fragment having the 370 bp pho5 terminator was isolated by electrophoresis and was ligated with pJDB207. From the resulting transformants, a clone having plasmid pPT2 (as shown in Fig. 3) was obtained. pPT2 is an E. coli-yeast shuttle vector possessing a pho5 terminator. In E. coli, it possesses an ampicillin resistance marker with β-lactamase activity and in yeast it has a marker to compensate for a leucine nutritional requirement.

(F) Human serum albumin gene

The DNA sequence coding for human serum albumin was derived from the plasmid pGX401 (Figs. 4 and 5) disclosed in Japanese Patent Application (OPI) No. 29985/87 or EP-A-206733 as follows. pGX401 was digested with the restriction enzymes XbaI and HindIII, and the DNA fragment (HSA2) of about 750 bp coding for the C-terminal side ^{357}Leu to ^{585}Leu of the amino acid sequence of human serum albumin,

including the 3′ untranslated region, was isolated by electrophoresis. The commercially available plasmid pUC19 was digested with XbaI and HindIII, was treated with alkaline phosphatase to dephosphorylated the 5′ terminal and was ligated with HSA2 with T4 DNA ligase. It was introduced into E. coli HB101, and from the resulting transformants, a clone having plasmid pHSA2 (as shown in Fig. 6) was obtained.

Upon digesting pGX401 with DraI and XbaI, a DNA fragment of about 1 kb was isolated by electrophoresis. This DNA fragment is the DNA sequence encoding for the N-terminal side ^{12}Lys to ^{356}Thr of the amino acid sequence of human serum albumin.

Using the DNA synthesizer Applied Biosystem model 381A, the following DNA sequence encoding for the N-terminal ^{1}Asp to ^{11}Phe of the amino acid sequence of mature human serum albumin was synthesized by the phosphoramidite method.

	1	2	3	4	5	6	7	8	9	10	11
	Asp	Ala	His	Lys	Ser	Glu	Val	Ala	His	Arg	Phe
TC	GAC G	GCA CGT	CAC GTG	AAG TTC	AGT TCA	GAG CTC	GTT CAA	GCT CGA	CAT GTA	CGG GCC	TTT AAA

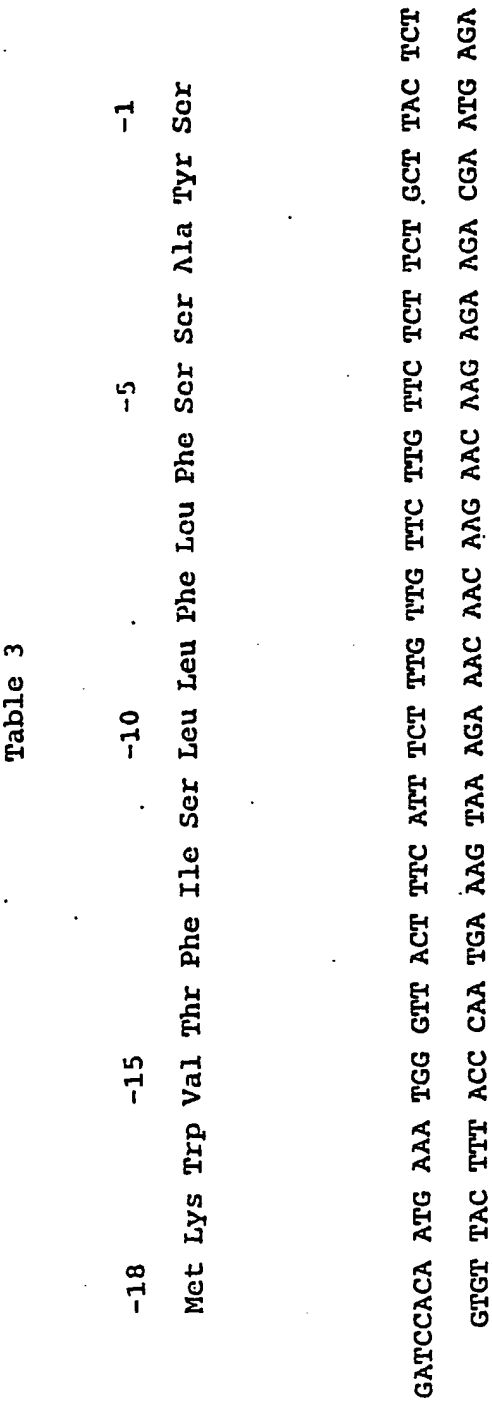
The codon for aspartic acid (Asp) in pGX401 was GAT, but GAC was used here. As a result, after ligating the synthetic DNA with the 1 kb DNA fragment derived from pGX401, the SalI site was regenerated when it was inserted into the SalI-XbaI site of pUC19. Furthermore, when digested with HinCII, the DNA sequence coding for the amino acid sequence starting from the N-terminal ^{1}Asp of mature human serum albumin was obtained.

The 5′ terminal of the synthetic DNA was phosphorylated by ATP and T4 polynucleotide kinase. pGX401 was digested with DraI and XbaI and 1 kb DNA fragment was isolated by electrophoresis. This fragment and the phosphorylated synthetic DNA were ligated with T4 ligase, digested with SalI and XbaI, and then ligated with pUC19 which was digested with SalI and XbaI and dephosphorylated by CIP. The resulting DNA was introduced into E. coli HB101, and from the transformants, a clone having the plasmid pHSA1 (as shown in Fig. 7) was obtained.

(G) Preparation of plasmid DNA for expressing and secreting human serum albumin in yeast

The DNA sequence shown in Table 3 below coding for the signal peptide of human serum albumin was synthesized by the phosphoramidite method by the DNA synthesizer Applied Biosystem model 381A.

Table 3



Also, the DNA sequence encoding the signal peptide amino acid which was changed to Arg or His, Ala or Pro, Lys or Gly, Val or Cys, Trp or Ser, Ala or Gly in the place of -17, -5, -4, -3, -2 and -1, respectively, was synthesized by the same method (cf. Table 2). The changed DNA sequence lead to produce and secrete the more proper N-terminal side of albumin.

The 5′ terminal of the synthetic DNA was phosphorylated with ATP and T4 polynucleotide kinase. pHSA1 was digested with XbaI and HincII, and the 1kb HSA1 DNA fragment encoding for the N-terminal side of human serum albumin was isolated by electrohphoresis. The phosphorylated synthetic DNA and

HSA1 were mixed and ligated with T4 DNA ligase, and digested further with XbaI and BamHI. After digesting pHSA2 with XbaI and BamHI, it was treated with alkaline phosphatase. After mixing, these DNAs were ligated with T4 DNA ligase and introduced into E. coli HB101 cells. Among the resulting transformants a clone having the plasmid pNH001 (as shown in Fig. 8) was obtained.

After digesting pNH001 with EcoRI and BamHI, it was treated with alkaline phosphatase. Then, pGAL12 was digested with EcoRI and BamHI, a DNA fragment of 1 kb possessing the GAL1 promoter was isolated by electrophoresis, mixed with the treated pNH001 and ligated with T4 DNA ligase. From the resulting transformants, a clone having the plasmid pNH007 (as shown in Fig. 9) was obtained. pNH007 is a plasmid DNA having the DNA sequence encoding for the human serum albumin signal peptide located downstream from the GAL1 promoter, the DNA sequence encoding for mature human serum albumin immediately after it, and immediately following that, the 3′ untranslated region derived from human serum albumin cDNA inserted in the EcoRI-HindIII site of pUC19.

After digesting pNH007 with EcoRI and HindIII, a DNA fragment of 2.7 kb coding for the GAL1 promoter, the signal peptide, mature human serum albumin and the untranslated region was isolated by electrophoresis. Additionally, pPT2 was digested with BamHI and treated with alkaline phosphatase. It was mixed with the 2.7 kb DNA fragment, and the sticky end was repaired by DNA poymerase I, Klenow fragment, in the presence of dATP, dGTP, dTTP, and dCTP. After ligation with T4 DNA ligase, it was introduced into E. coli HB101. From the resulting transformants, a clone having the plasmide pNH008 (as shown in Fig. 10) was obtained.

pNH008 is a plasmid capable of self-replication in E. coli and yeast and possesses the DNA sequence encoding for the human serum albumin signal peptide and the succeeding mature human serum albumin protein under the control of the GAL1 promoter functionable in yeast. Furthermore, pNH008 also possesses a gene for ampicillin resistance in E. coli, and a gene for fulfilling the nutritional requirement for leucine in yeast, and these genes can be used as selective marker for transformants.

(H) Introduction of plasmid pNH008 into Yeast

Plasmid pNH008, for the secretory expression of human serum albumin, was introduced into yeast Saccharomyces cerevisiae AH22 (Proc. Natl. Acad. Sci. USA, 75, 1929-1933 (1978)) by the following method.

S. cerevisiae AH22 was subjected to shaking culture overnight at 30°C in 50 mℓ of YPD medium. (To prepare the medium, 10 g of yeast extract and 20 g of bactopeptone were dissolved in water to make up 900 mℓ, which was sterilized in an autoclave and mixed with 100 mℓ of 20 w/v% glucose separately sterilized in an autoclave). The cells were precipitated by centrifugation, resuspended in 20 mℓ of water, and centrifuged again. Next, the cells were suspended in 10 mℓ of 50 mM dithiothreitol, 1.2 M sorbitol, 2 mM EDTA at pH 8.5, and were shaken slowly for 10 minutes at 30°C. The cells were collected by centrifugation, and suspended in 10 mℓ of 1.2 M sorbitol, then centrifuged again for collection. The cells were suspended in 10 mℓ of 0.2 mg/mℓ zymolyase 100T, 1.2 M sorbitol, 10 mM EDTA, 0.1 M sodium citrate at pH 5.8, and were shaken slowly for 1 hour at 30°C. The cells were collected by centrifugation and washed in 10 mℓ each of 1.2 M sorbitol, 10 mM calcium chloride and 1.2 M sorbitol, sequentially, and again the cells were collected by centrifugation. The cells were suspended in 1 mℓ of 10 mM calcium chloride and 1.2 M sorbitol. One hundred microliter aliquotes of suspension were placed in a sterile test tube and mixed with 5 μℓ (5 μg) of pNH008; the mixture was allowd to stand for 15 minutes at room temperature. After this, it was mixed with 1.2 mℓ of 20 w/v% polyethylene glycol 4,000, 10 mM calcium chloride, 10 mM tris-hydrochloride at pH 7.5, and after gentle mixing, the mixture was let stand at room temperature for 20 minutes. The cells were collected by centrifugation, suspended in 0.1 mℓ of YPD medium containing 1.2 M sorbitol and 10 mM calcium chloride, and shaken gently for 30 minutes at 30°C. 1, 5, 10, 20 and 50 μℓ of suspension were suspended in 45°C-controlled 10 mℓ of 1.2 M sorbitol, 3 w/v% noble agar, 2 w/v% glucose, and 0.7 w/v% yeast nitrogen base and were spread over plates composed of 1.2 M sobitol, 3 w/v% bactoagar, 2 w/v% glucose, and 0.7 w/v% yeast nitrogen base. After the plates solidified, they were subjected to stationary culture for 3 days at 30°C. Formed colonies were collected by a sterile toothpick suspended in 3 mℓ of 0.7 w/v% yeast nitrogen base and 2 w/v% glucose, and subjected to shaking culture for 2 days at 30°C. One and a half milliliters of suspension was centrifuged, and the cells were collected and suspended in 3 mℓ of YPG medium. (To prepare the culture, 10 g of yeast extract and 20 g of bactopeptone were dissolved in water to make up 900 mℓ, sterilized in an autoclave, and mixed with 100 mℓ of 20 w/v% galactose, sterilized separately in an autoclave.) This was subjected to shaking culture at 30°C. The human serum albumin concentration in the culture supernatant was measured by the

RPHA method (as described in European Patent 122,620), and a maximum human serum albumin of 10 µg/mℓ was detected on the first day.

(l) Cultivation of yeast for the expression and secretion of human serum albumin

The yeast S. cerevisiae AH22 for the expression and secretion human serum albumin tranformed by pNH008 as mentioned above was cultivated by the following procedure. The recombinant yeast was grown in a plate containing 0.7 w/v% yeast nitrogen base, 2 w/v% glucose and 3 w/v% bactoagar and collected by a platinum loop. It was inoculated into YNB medium 50 mℓ composed of 0.7 w/v% yeast nitrogen base and 2 w/v% glucose and incubated for 2 days at 30° C. The whole volume was inoculated into 500 mℓ of YNB medium and incubated for 2 days at 30° C. The cells were collected by centrifugation, and suspended in 500 mℓ of YPG medium, and subjected to shaking culture at 30° C. A portion of the culture broth was collected after 0, 3, 6, 24 and 48 hours of incubation, and the culture supernatant was obtained by centrifugation. The concentration of human serum albumin secreted into the culture broth was measured by the RPHA method. Secretory expression of human serum albumin was detected beginning the third hour after the start of incubation, and the concentration of human serum albumin in the supernatant was 0.25 mg/ℓ at 6 hours, 20 mg/ℓ at 24 hours, and 160 mg/ℓ at 48 hours.

Claims

1. A method for preparing foreign protein comprising expressing and secreting said foreign protein by yeast transformed by a recominant DNA comprising the serum albumin signal peptide gene adjacent to the gene of said foreign protein, a promoter upstream to said serum albumin signal peptide gene and a terminator downstream to said foreign protein gene.

2. The method as set forth in Claim 1, wherein the serum albumin signal peptide is human derived.

3. The method as set forth in Claim 1, wherein the serum albumin signal peptide gene is expressed in the following amino acid sequence.

Met Y Trp Val Thr Phe Ile Ser Leu Leu Phe Leu Phe
X_5 X_4 X_3 X_2 X_1

wherein Y represents Lys, Arg, or His; X_5 represents Ala, Pro or Ser; X_4 represents Lys, Gly or Ser; X_3 represents Ala, Val or Cys; X_2 represents Tyr, Trp or Ser; and X_1 represents Ser, Ala or Gly.

4. A serum albumin signal peptide gene encoding the following amino acid sequence.

Met Y Trp Val Thr Phe Ile Ser Leu Leu Phe Leu Phe
X_5 X_4 X_3 X_2 X_1

wherein Y represents Lys, Arg or His; X_5 represents Ala, Pro or Ser; X_4 represents Lys, Gly or Ser; X_3 represents Ala, Val or Cys; X_2 represents Tyr, Trp or Ser; and X_1 represents Ser, Ala or Gly.

5. A recombinant DNA for transforming yeast comprising DNA encoding the serum albumin signal peptide adjacent to DNA encoding a foreign protein, a promoter upstream to the serum albumin signal peptide gene and a terminator downstream to the foreign protein gene.

6. A strain of yeast transformed by a recominant DNA comprising DNA encoding the serum albumin signal peptide adjacent to DNA encoding a foreign protein, a promoter upstream to the serum albumin signal peptide gene and a terminator downstream to the foreign protein gene.

7. The method as set forth in Claim 1, wherein the amino acid sequence of said serum albumin signal peptide is selected from the group consisting of:
MetLysTrpValThrPheIleSerLeuLeuPheLeuPheSerSerAlaTyrSer,
MetLysTrpValThrPheLeuLeuLeuLeuPheIleSerGlySerAlaPheSer,
MetLysTrpValThrPheIleSerLeuLeuLeuLeuPheSerSerAlaTyrSer,
MetLysTrpValThrPheIleSerLeuLeuPheLeuPheSerSerValTyrAla,
MetLysTrpValThrPheIleSerLeuLeuPheLeuPheAlaLysValSerAla,
MetLysTrpValThrPheIleSerLeuLeuPheLeuPheProGlyCysTrpAla,
and
MetLysTrpValThrPheIleSerLeuLeuPheLeuPheProGlyValTrpAla.

8. The method as set forth in Claim 1, wherein said serum albumin signal peptide gene has the following DNA sequence:
ATGAAGTGGGTAACCTTTATTTCCCTT
CTTTTTCTCTTTAGCTCGGCTTATTCC.

9. The method as set forth in Claim 1, wherein said foreign protein is selected from the group consisting of human serum albumin, interferon-α, interferon-β, interferon-γ, urokinase, growth hormone, insulin, lymphokines, h-ANP, Factor VIII, CSFs and EPO.

10. The method as set forth in Claim 1, the foreign protein gene is the mature human serum albumin gene which is positioned immediately downstream to the serum albumin signal peptide gene.

Claims for the following Contracting State: ES

1. A method for preparing foreign protein comprising expressing and secreting said foreign protein by yeast transformed by a recombinant DNA comprising the serum albumin signal peptide gene adjacent to the gene of said foreign protein, a promoter upstream to said serum albumin signal peptide gene and a terminator downstream to said foreign protein gene.

2. The method as set forth in Claim 1, wherein the serum albumin signal peptide is human derived.

3. The method as set forth in Claim 1, wherein the serum albumin signal peptide gene is expressed in the following amino acid sequence.

Met Y Trp Val Thr Phe Ile Ser Leu Leu Phe Leu Phe

X_5 X_4 X_3 X_2 X_1

wherein Y represents Lys, Arg or His; X_5 represents Ala, Pro or Ser; X_4 represents Lys, Gly or Ser; X_3 represents Ala, Val or Cys; X_2 represents Tyr, Trp or Ser; and X_1 represents Ser, Ala or Gly.

4. The method as set forth in Claim 1, wherein the amino acid sequence of said serum albumin signal peptide is selected from the group consisting of:

MetLysTrpValThrPheIleSerLeuLeuPheLeuPheSerSerAlaTyrSer,

MetLysTrpValThrPheLeuLeuLeuLeuPheIleSerGlySerAlaPheSer,

MetLysTrpValThrPheIleSerLeuLeuLeuLeuPheSerSerAlaTyrSer,

MetLysTrpValThrPheIleSerLeuLeuPheSerSerValTyrAla,

MetLysTrpValThrPheIleSerLeuLeuPheLeuPheAlaLysValSerAla,

MetLysTrpValThrPheIleSerLeuLeuPheLeuPheProGlyCysTrpAla,

and

MetLysTrpValThrPheIleSerLeuLeuPheLeuPheProGlyValTrpAla.

5. The method as set forth in Claim 1, wherein said serum albumin signal peptide gene has the following DNA sequence:

ATGAAGTGGGTAACCTTTATTTCCCTT

CTTTTTCTCTTTAGCTCGGCTTATTCC.

6. The method as set forth in Claim 1, wherein said foreign protein is selected from the group consisting of human serum albumin, interferon-α, interferon-β, interferon-γ, urokinase, growth hormone, insulin, lymphokines, h-ANP, Factor VIII, CSFs and EPO.

7. The method as set forth in Claim 1, the foreign protein gene is the mature human serum albumin gene which is positioned immediately downstream to the serum albumin signal peptide gene.

FIG. 1

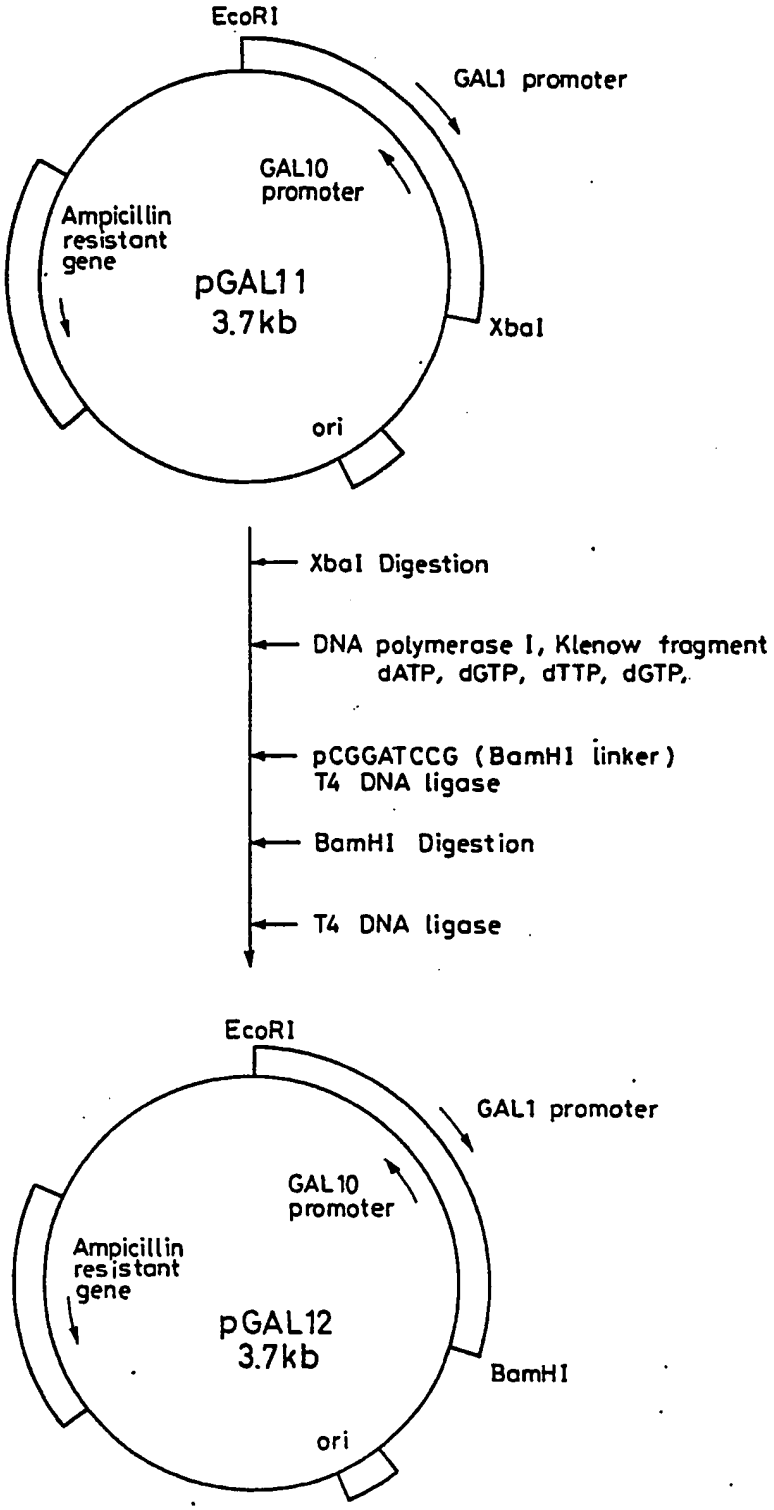

EcoRI
GAL1 promoter
GAL10 promoter
Ampicillin resistant gene
pGAL11
3.7kb
XbaI
ori
XbaI Digestion
DNA polymerase I, Klenow fragment
dATP, dGTP, dTTP, dGTP,
pCGGATCCG (BamHI linker)
T4 DNA ligase
BamHI Digestion
T4 DNA ligase
EcoRI
GAL1 promoter
GAL10 promoter
Ampicillin resistant gene
pGAL12
3.7kb
BamHI
ori

FIG. 2

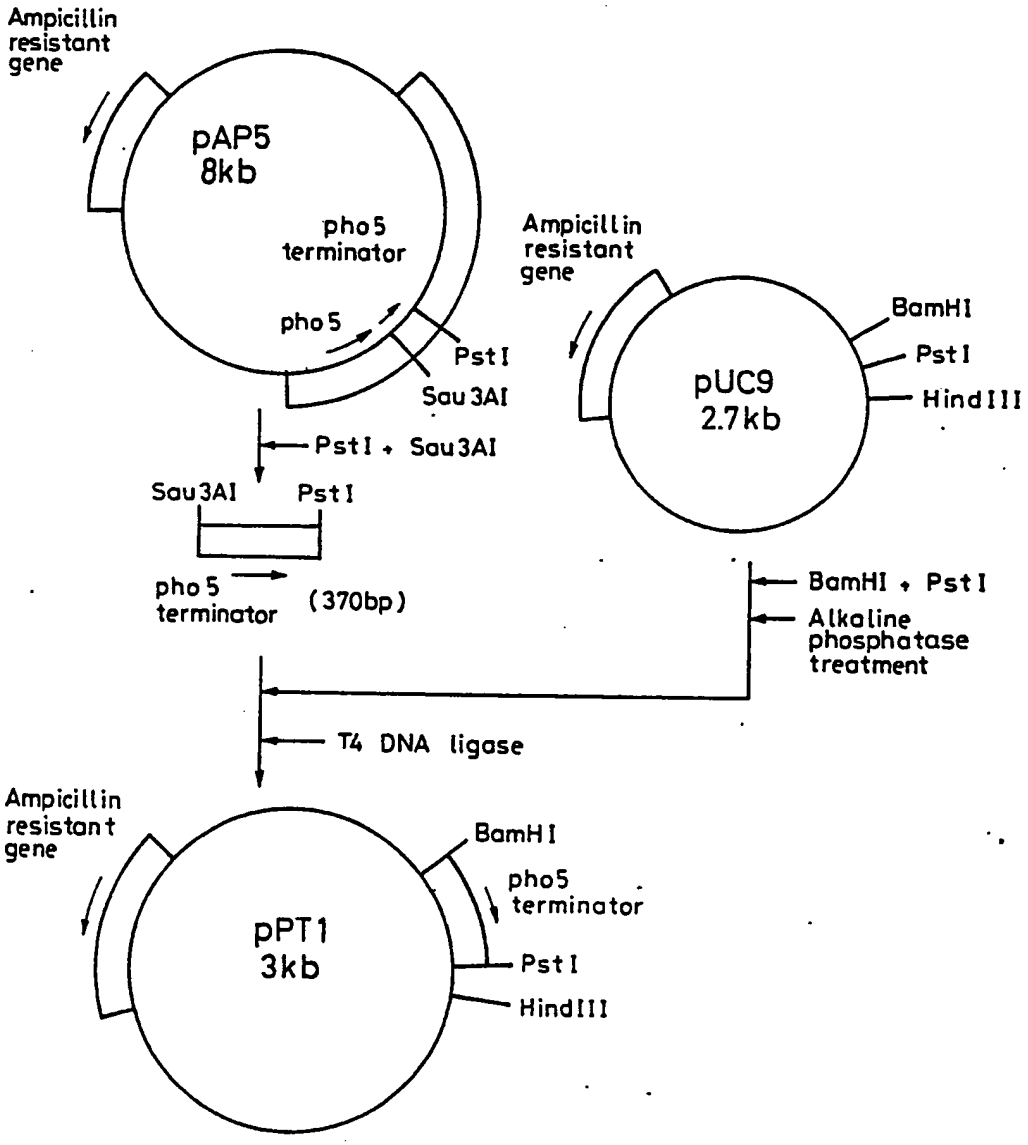

Ampicillin resistant gene
pAP5 8kb
pho5 terminator
pho5
PstI
Sau3AI
PstI + Sau3AI
Sau3AI
PstI
pho5 terminator
(370bp)
Ampicillin resistant gene
pUC9 2.7kb
BamHI
PstI
HindIII
BamHI + PstI
Alkaline phosphatase treatment
T4 DNA ligase
Ampicillin resistant gene
pPT1 3kb
BamHI
pho5 terminator
PstI
HindIII

FIG. 3

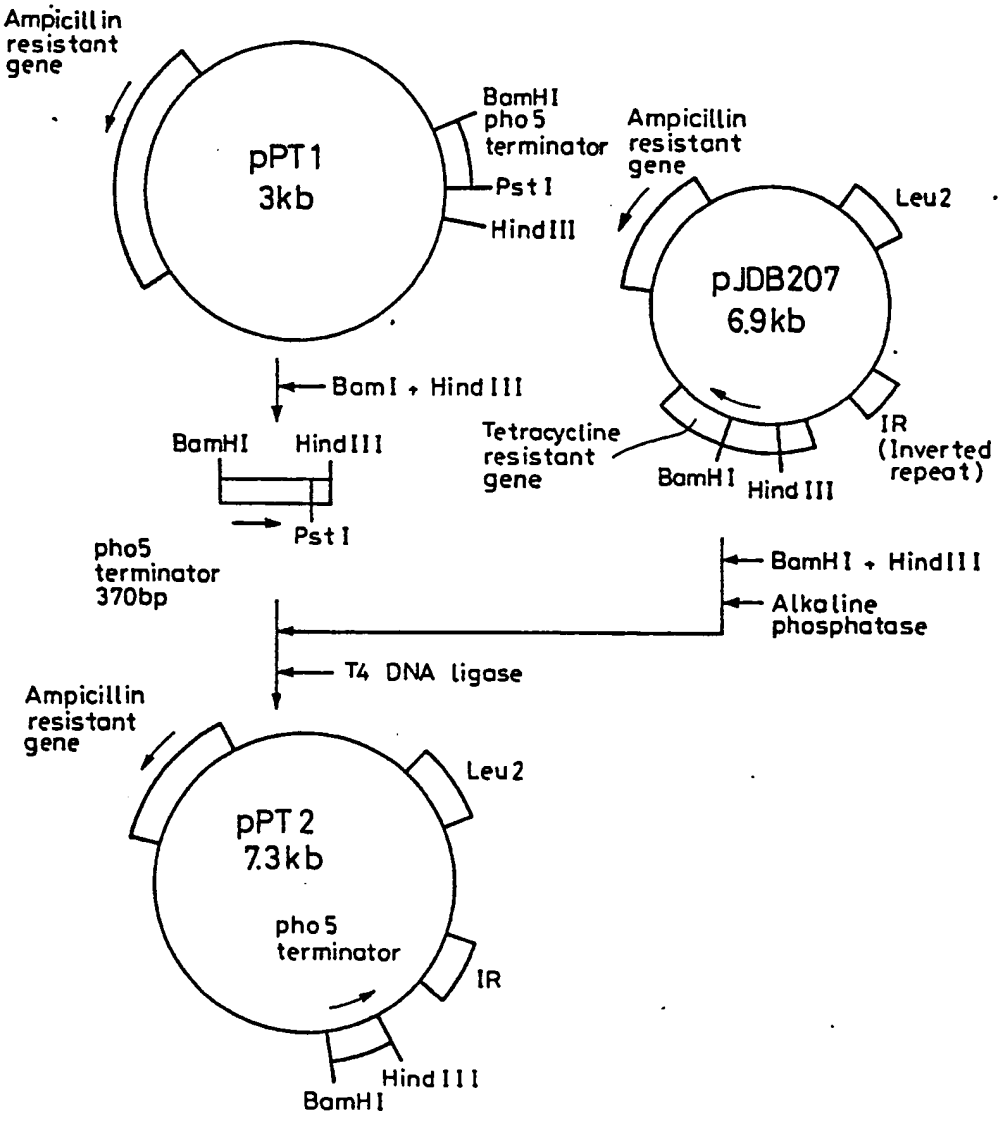

Ampicillin resistant gene
pPT1
3kb
BamHI
pho5 terminator
Pst I
Hind III
Ampicillin resistant gene
pJDB207
6.9kb
Leu2
IR (Inverted repeat)
Tetracycline resistant gene
BamHI
Hind III
Bam I + Hind III
BamHI
Hind III
Pst I
pho5 terminator 370bp
BamHI + Hind III
Alkaline phosphatase
T4 DNA ligase
Ampicillin resistant gene
pPT2
7.3kb
Leu2
pho5 terminator
IR
Hind III
BamHI

FIG. 4

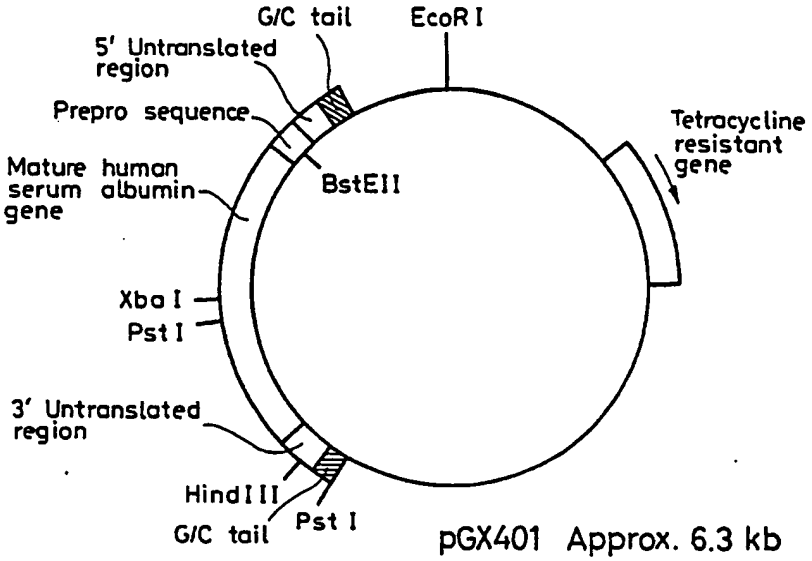

G/C tail
EcoR I
5' Untranslated region
Prepro sequence
Mature human serum albumin gene
BstEII
Tetracycline resistant gene
Xba I
Pst I
3' Untranslated region
Hind III
G/C tail
Pst I
pGX401 Approx. 6.3 kb

FIG. 5

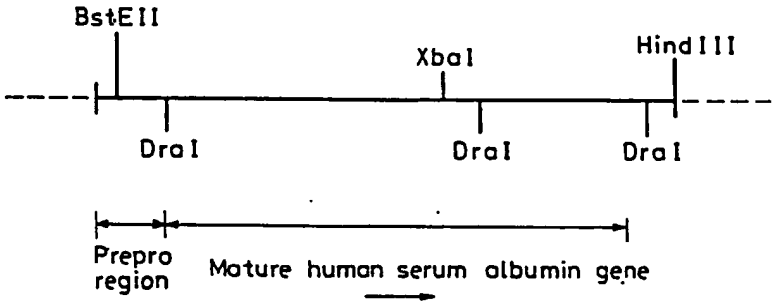

BstEII
Xba I
Hind III
Dra I
Dra I
Dra I
Prepro region
Mature human serum albumin gene

FIG. 6

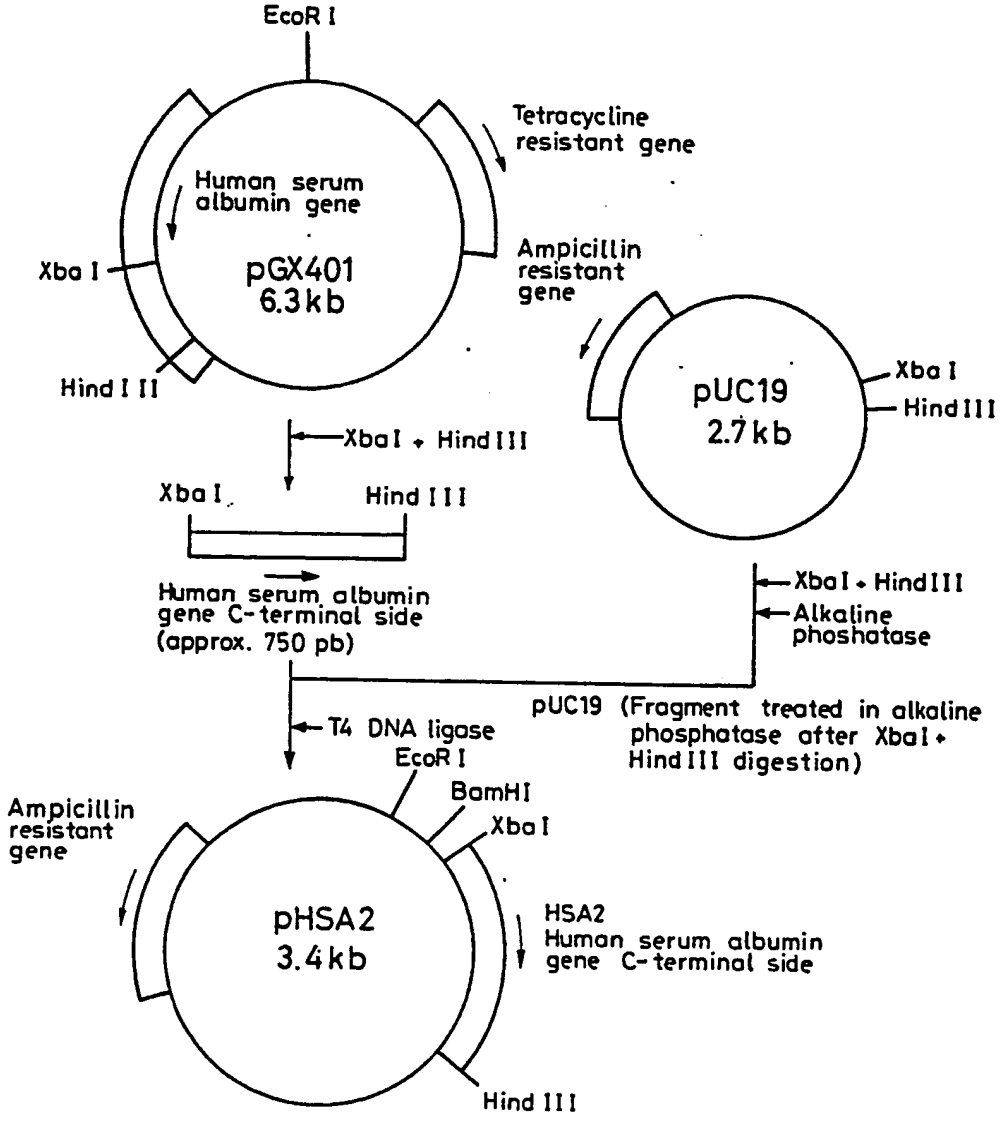

EcoR I
Tetracycline resistant gene
Human serum albumin gene
pGX401
6.3kb
Xba I
Hind I II
Ampicillin resistant gene
pUC19
2.7kb
Xba I
Hind III
Xba I + Hind III
Xba I
Hind III
Human serum albumin gene C-terminal side (approx. 750 pb)
Xba I + Hind III
Alkaline phoshatase
pUC19 (Fragment treated in alkaline phosphatase after Xba I + Hind III digestion)
T4 DNA ligase
EcoR I
BamHI
Xba I
Ampicillin resistant gene
pHSA2
3.4kb
HSA2
Human serum albumin gene C-terminal side
Hind III

FIG. 7

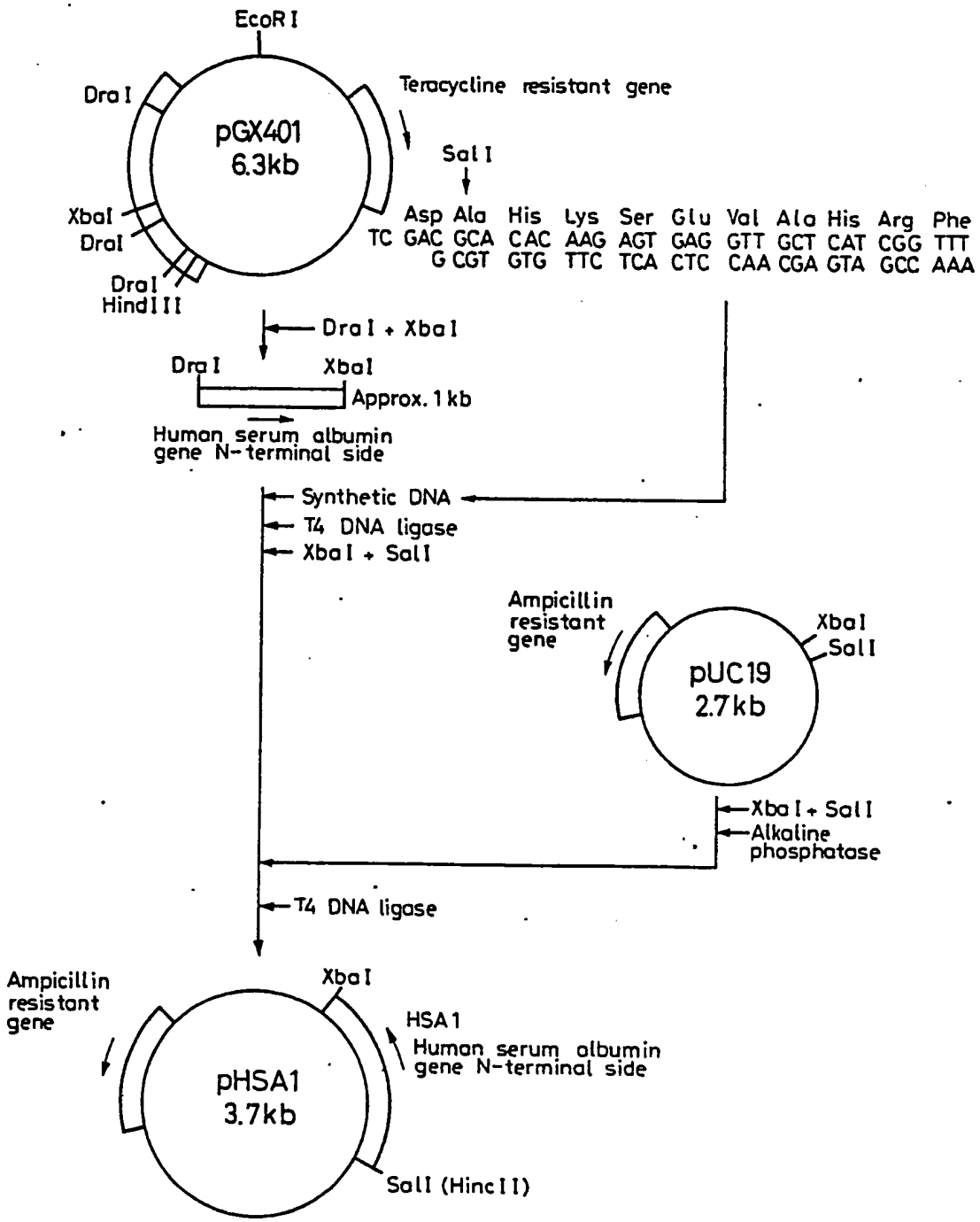

EcoR I
Dra I
pGX401
6.3kb
Teracycline resistant gene
Sal I
Xba I
Dra I
Dra I
Hind III
Asp Ala His Lys Ser Glu Val Ala His Arg Phe
TC GAC GCA CAC AAG AGT GAG GTT GCT CAT CGG TTT
G CGT GTG TTC TCA CTC CAA CGA GTA GCC AAA
Dra I + Xba I
Dra I
Xba I
Approx. 1 kb
Human serum albumin gene N-terminal side
Synthetic DNA
T4 DNA ligase
Xba I + Sal I
Ampicillin resistant gene
pUC19
2.7kb
Xba I
Sal I
Xba I + Sal I
Alkaline phosphatase
T4 DNA ligase
Ampicillin resistant gene
Xba I
HSA 1
Human serum albumin gene N-terminal side
pHSA1
3.7kb
Sal I (Hinc II)

FIG. 8

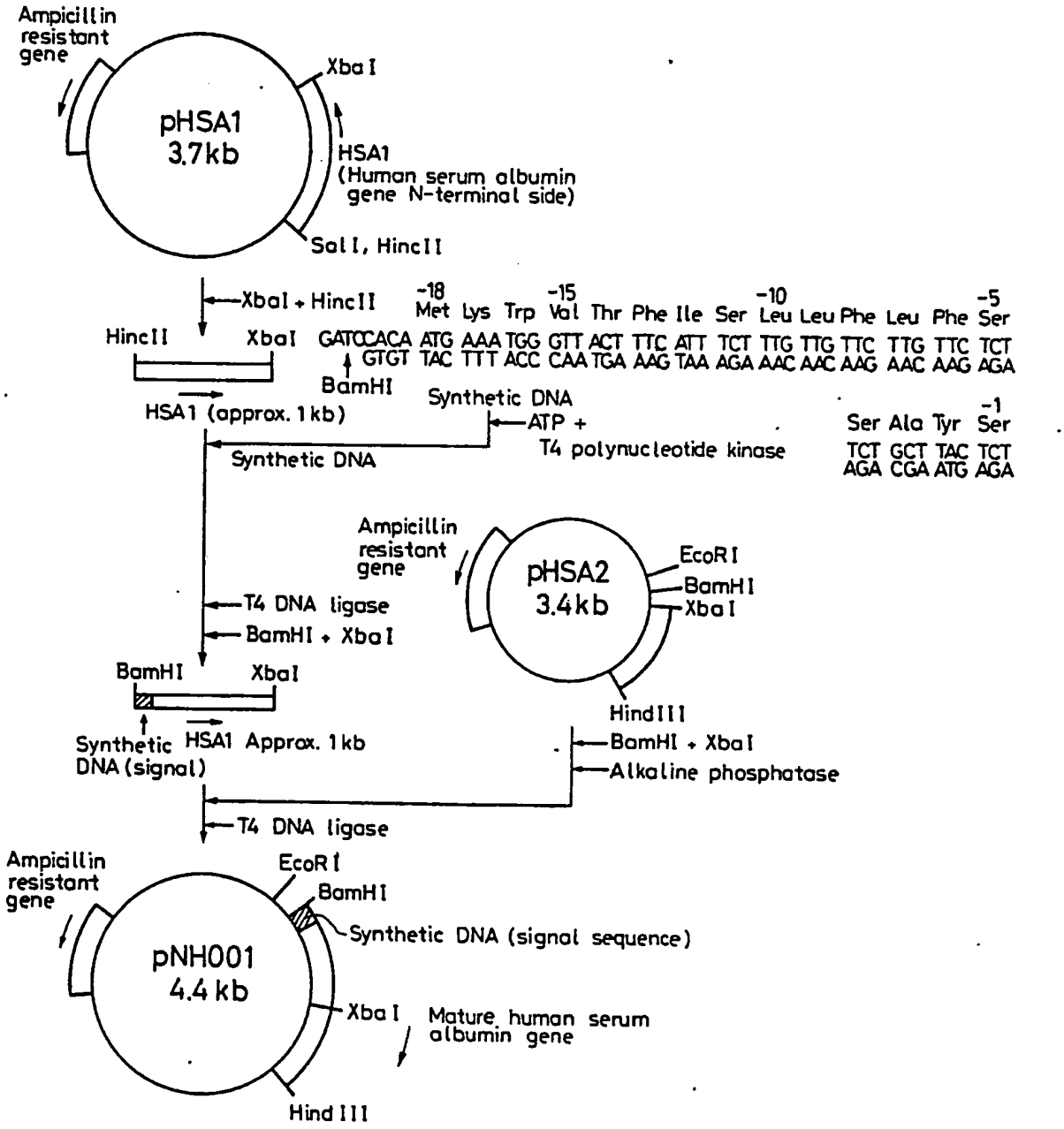

Ampicillin resistant gene
pHSA1 3.7kb
XbaI
HSA1 (Human serum albumin gene N-terminal side)
SalI, HincII
XbaI + HincII
HincII
XbaI
GATCCACA ATG AAA TGG GTT ACT TTC ATT TCT TTG TTG TTC TTG TTC TCT
GTGT TAC TTT ACC CAA TGA AAG TAA AGA AAC AAC AAG AAC AAG AGA
BamHI
HSA1 (approx. 1kb)
Synthetic DNA
ATP +
T4 polynucleotide kinase
Synthetic DNA
-18 -15 -10 -5
Met Lys Trp Val Thr Phe Ile Ser Leu Leu Phe Leu Phe Ser
-1
Ser Ala Tyr Ser
TCT GCT TAC TCT
AGA CGA ATG AGA
Ampicillin resistant gene
pHSA2 3.4kb
EcoRI
BamHI
XbaI
HindIII
T4 DNA ligase
BamHI + XbaI
BamHI
XbaI
Synthetic DNA (signal)
HSA1 Approx. 1kb
BamHI + XbaI
Alkaline phosphatase
T4 DNA ligase
Ampicillin resistant gene
pNH001 4.4 kb
EcoRI
BamHI
Synthetic DNA (signal sequence)
XbaI
Mature human serum albumin gene
HindIII

FIG. 9

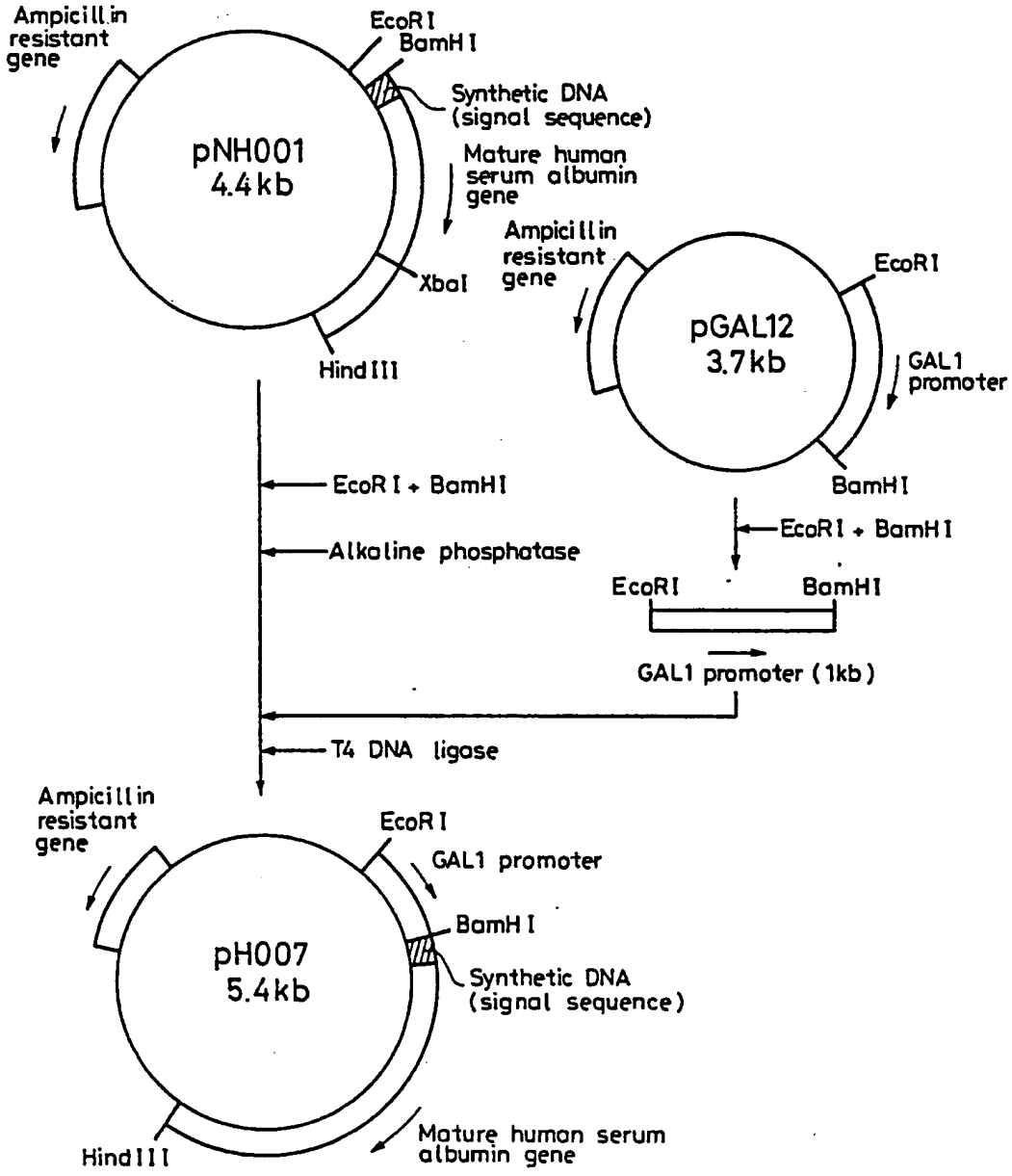
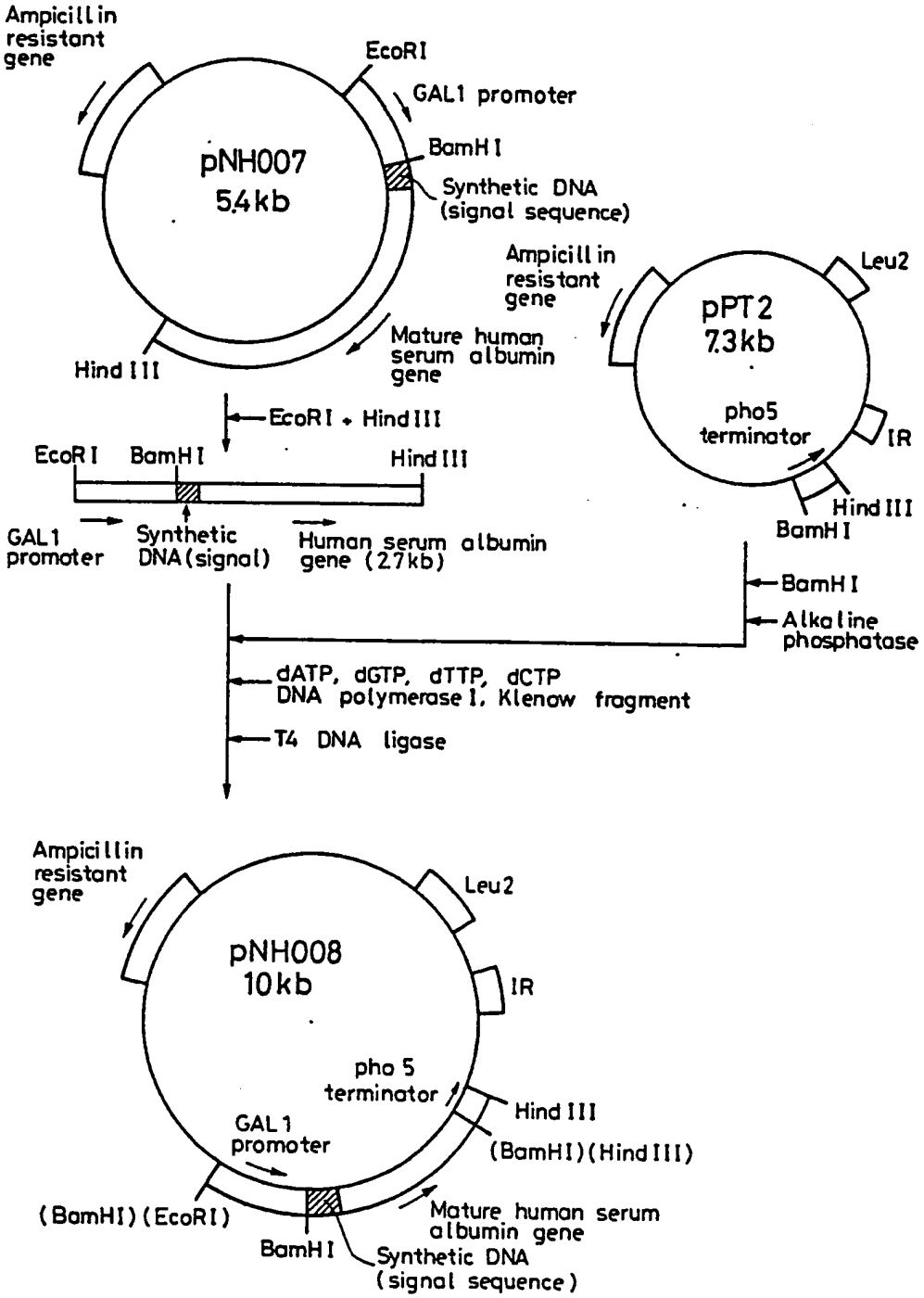

Ampicillin resistant gene
EcoR I
BamH I
Synthetic DNA (signal sequence)
pNH001 4.4kb
Mature human serum albumin gene
Xba I
Hind III
Ampicillin resistant gene
EcoR I
pGAL12 3.7kb
GAL1 promoter
BamH I
EcoR I + BamH I
Alkaline phosphatase
EcoR I + BamH I
EcoR I
BamH I
GAL1 promoter (1kb)
T4 DNA ligase
Ampicillin resistant gene
EcoR I
GAL1 promoter
BamH I
pH007 5.4kb
Synthetic DNA (signal sequence)
Hind III
Mature human serum albumin gene

FIG. 10


Ampicillin resistant gene
EcoRI
GAL1 promoter
BamHI
Synthetic DNA (signal sequence)
pNH007
5.4kb
Hind III
Mature human serum albumin gene
EcoRI + Hind III
EcoRI
BamHI
Hind III
GAL1 promoter
Synthetic DNA (signal)
Human serum albumin gene (2.7kb)
Ampicillin resistant gene
Leu2
pPT2
7.3kb
pho5 terminator
IR
Hind III
BamHI
BamHI
Alkaline phosphatase
dATP, dGTP, dTTP, dCTP
DNA polymerase I, Klenow fragment
T4 DNA ligase
Ampicillin resistant gene
Leu2
pNH008
10kb
IR
pho 5 terminator
Hind III
(BamHI)(Hind III)
GAL1 promoter
(BamHI)(EcoRI)
Mature human serum albumin gene
BamHI
Synthetic DNA (signal sequence)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 10 7087

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	EP-A-0 079 739 (THE UPJOHN COMPANY) * abstract; page 1, lines 26-28; page 2, line 36 - page 3, line 15; claims 5-13,15-17 *	4	C 12 N 15/00 C 12 P 21/00
A		1-3,5-10	

D,X	EP-A-0 206 733 (GENEX CORPORATION) * abstract; page 10, lines 3-11; page 11, line 16 - page 12, line 7; page 12, lines 13-15; figures 1-2; claims *	4,9-10	
D,A		1-3,5-8	

X	EP-A-0 236 210 (GENETICA) * abstract; page 3, lines 1-16; page 4, lines 14-19; figure 1; claims *	2-3,5-10	
A		1-3,5-10	

A	EP-A-0 038 182 (PRESIDENT AND FELLOWS OF HARVARD COLLEGE) * whole document *	1-10	TECHNICAL FIELDS SEARCHED (Int. Cl.4)

D,A	PROC. NATL. ACAD. SCI. U.S.A. vol. 79, January 1982, pages 71-75, Washington, US; A. DUGAICZYK et al.:"Nucleotide sequence and the encoded amino acids of human serum albumin mRNA" * whole document *	1-10	C 12 N 15/00
	--- -/-		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	25-02-1989	JULIA P.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 10 7087

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	EUR. J. BIOCHEM. vol. 98, no. 2, 1979, pages 477-485, Berlin; R.T.A. MACGILLIVRAY et al.:"Biosynthesis of Bovine Plasma Proteins in a Cell-Free System" * whole document *	4	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	25-02-1989	JULIA P.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)